

MILITARY SPECIFICATION

TRANSISTOR, NPN, SILICON  
 TYPES 2N2015, 2N2016

1. SCOPE

1.1 Scope.- This specification covers the detail requirements for silicon, NPN, transistors for use in high-power circuit applications and having the following particular characteristics at  $T_A = +25^\circ \pm 3^\circ\text{C}$ . (See 3.2 herein):

	$h_{FE}$		$I_{CBO}$	$I_{EBO}$	$V_{BE}$	$V_{CE} \text{ (sat)}$
	(at: $I_C = 5 \text{ A dc}$ $V_{CE} = 4.0 \text{ V dc}$ )	(at: $I_C = 10 \text{ A dc}$ $V_{CE} = 4.0 \text{ V dc}$ )	(at: $V_{CB} = 30 \text{ V dc}$ $I_E = 0$ )	(at: $V_{EB} = 10 \text{ V dc}$ $I_C = 0$ )	(at: $I_C = 5 \text{ A dc}$ $V_{CE} = 4.0 \text{ V dc}$ )	(at: $I_C = 5 \text{ A dc}$ $I_B = 0.5 \text{ A dc}$ )
	---	---	$\frac{\mu\text{A dc}}{}$	$\frac{\mu\text{A dc}}{}$	$\frac{\text{V dc}}{}$	$\frac{\text{V dc}}{}$
Minimum	15	7.5	---	---	---	---
Maximum	50	---	50	50	2.2	1.25

1.2 Maximum ratings.-

$V_{CBO}$		$V_{EBO}$	$V_{CEX}$		$V_{CEO} \text{ (sus)}$	
2N2015	2N2016		2N2015	2N2016	2N2015	2N2016
$\frac{\text{V dc}}{100}$	$\frac{\text{V dc}}{130}$	$\frac{\text{V dc}}{10}$	$\frac{\text{V dc}}{100}$	$\frac{\text{V dc}}{130}$	$\frac{\text{V dc}}{50}$	$\frac{\text{V dc}}{65}$

$P_C$ <sup>1/</sup>	$I_C$	$I_B$	$\theta_{J-C}$	$T_J$	$T_{stg}$	Altitude
$\frac{\text{W}}{150}$	$\frac{\text{A dc}}{10}$	$\frac{\text{A dc}}{6}$	$\frac{^\circ\text{C/W}}{1.17}$	$\frac{^\circ\text{C}}{+200}$	$\frac{^\circ\text{C}}{-65 \text{ to } +200}$	$\frac{\text{ft}}{100,000}$

<sup>1/</sup> This power dissipation is for 1,000 hours expected life at a mounting temperature of  $+25^\circ \pm 3^\circ\text{C}$ . For power dissipation at mounting temperatures up to  $+200^\circ\text{C}$ , derate at  $0.86 \text{ W/}^\circ\text{C}$ .

## 2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

## SPECIFICATIONS

**MILITARY**

MIL-S-19500

# Semiconductor Devices, General Specification For

## STANDARDS

## MILITARY

MIL-S1 D-750

## Test Methods For Semiconductor Devices

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer. Both the title and number or symbol should be stipulated when requesting copies.)

### 3. REQUIREMENTS

3.1 General. - Requirements for the transistors shall be in accordance with Specification MIL-S-19500, and as otherwise specified herein.

**3.2 Abbreviations and symbols.**- The abbreviations and symbols used herein are defined in Specification MIL-S-19500 and as follows:

PC ..... collector power dissipation  
 $V_{CEO(sus)}$ ..... collector-to emitter voltage, open base, sustaining  
 $V_{CEX}$ ..... collector-to-emitter voltage, emitter-to-base reverse biased

**3.3 Design and construction.** - The transistors shall be of the design, construction, and physical dimensions specified in Figure 1 herein.

**3.3.1 Terminal arrangement.** - The terminal arrangement on the transistors shall be as indicated in Figure 1 therein.

3.3.2 Operating position. - The transistors shall be capable of proper operation in any position.

3.4 Performance characteristics. - The transistor performance characteristics shall be as specified in Tables I, II, and III herein. Except where specifically differentiated for respective transistor types (see 1.1, 1.2, and Tables I, II, and III herein), the performance requirements, including characteristics, ratings, test conditions, and test limits, apply equally to both transistor types covered herein.

3.5 Marking. - The transistor shall be marked in accordance with Specification MIL-S-19500 and as follows. When the diminutive size or lack of suitable surface area prevents routine marking, on the device, of all items required by Specification MIL-S-19500, the following items may be omitted in the following preferred order: color-band type identification (if specified for the device), country of origin, manufacturer's identification. Where only a minimum of items can suitably be marked on the device, first consideration shall be given to marking the complete type designation (see 3.5.1 herein), and then to inclusion of the acceptance date and inspection lot identification. However, all required marking shall be placed on the unit package.

3.5.1 Complete type-designation marking. - Complete type-designation marking of transistors procured on Department of Army contracts, and which have passed Government inspection and comply with all requirements of this specification, shall consist of: "USA-manufacturer's qualification code letters-transistor designation (including any assigned reliability indicator.)" The letters "JAN" or any abbreviation thereof shall not be used. If any specification waiver has been granted, the combination "USA-manufacturer's qualification code letters" shall not be used to complete the type-designation marking.

#### 4. QUALITY ASSURANCE PROVISIONS

4.1 General. - Except as otherwise specified herein, the responsibility for inspection, general procedures for acceptance, classification of inspection, and inspection conditions and methods of test shall be in accordance with Specification MIL-S-19500, Quality Assurance Provisions.

4.1.1 Responsibility for inspection. - Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Qualification and Acceptance Inspection. - Qualification and Acceptance Inspection shall be in accordance with Specification MIL-S-19500, Quality Assurance Provisions, and as otherwise specified herein. Groups A, B, and C Inspection shall consist of the examinations and tests specified in Tables I, II, and III, respectively, herein. Acceptance Inspection shall include inspection of Preparation for Delivery (see 5.1 herein).

4.2.1 Specified LTPD for subgroups. - The LTPD specified for a subgroup in Tables I, II, and III herein shall apply for all of the tests, combined, in the subgroup. (See 6.2 herein.)

4.2.2 Mechanical damage resulting from tests. - Except for intentional deforming, mutilating, or dismembering mechanical-stress tests to which samples are subjected, there shall be no evidence of mechanical damage to any sample unit as a result of any of the Group A, B, or C tests.

4.2.3 Destructive tests. - The Group B, Subgroups 2, 3, 5, 6, 7, and 8 tests are considered destructive. However, the tests of Subgroups 2, 3, 6, 7, and 8 can be considered non-destructive if sufficient evidence is presented to the Government inspection authority to that effect. Acceptable evidence, for example, would be repeating of all Subgroups 2, 3, 6, 7, and 8 tests, ten times, without significant device degradation. This test repetition procedure need be done only once at inception of Acceptance Inspection, provided no change in design, or of production techniques, has been effected.

4.2.4 Disposition of sample units. - Sample units that have been subjected to Group B, Subgroup 5 test shall not be delivered on the contract or order. Sample units that have been subjected to and have passed Group B, Subgroups 2, 3, 6, 7, and 8 tests not determined to be destructive tests may be delivered on the contract or order provided that, after Group B inspection is terminated, those sample units are subjected to and pass Group A inspection. Defective units from any sample group that may have passed group inspection shall not be delivered on the contract or order until the defect(s) has been remedied to the satisfaction of the Government.

#### 4.3 Particular examination and test procedures. -

4.3.1 Collector-Emitter Voltage, Open Base, Sustaining test. - The specified currents shall be applied, under the specified test conditions, and the collector-to-emitter voltage shall then be measured.

4.3.2 Collector-Emitter Voltage, Emitter-To-Base Reverse Biased test. - The specified current and voltage shall be applied, under the specified test conditions, and the collector-to-emitter voltage shall then be measured.

4.3.3 Base-Emitter Voltage test. - The specified current and voltage shall be applied, and the dc base-to-emitter voltage shall then be measured.

Table 1. Group A inspection.

Test Method per MIL-STD-750	Examination or test	Conditions <u>1/</u>	LTPD	Symbol	Limits		Unit
					Min.	Max.	
	<u>Subgroup 1</u>		10				
2071	Visual and mechanical examination	---		---	---	---	---
	<u>Subgroup 2</u>		5				
3036	Collector-base cutoff current	Bias Cond. D $V_{CB} = 30 \text{ Vdc}$ $I_E = 0$		$I_{CBO}$	---	50	$\mu\text{Adc}$
<u>2/</u>	Collector-emitter voltage, open base, sustaining:	$I_C = 200 \text{ mAdc}$ $I_B = 0$					
	2N2015			$V_{CEO(sus)}$	50	---	Vdc
	2N2016			$V_{CEO(sus)}$	65	---	Vdc
<u>3/</u>	Collector-emitter voltage, emitter-to-base reverse biased:	$I_C = 2.0 \text{ mAdc}$ $V_{EB} = 1.5 \text{ Vdc}$					
	2N2015			$V_{CEX}$	100	---	Vdc
	2N2016			$V_{CEX}$	130	---	Vdc
3061	Emitter-base cutoff current	Bias Cond. D $V_{EB} = 10 \text{ Vdc}$ $I_C = 0$		$I_{EBO}$	---	50	$\mu\text{Adc}$
	<u>Subgroup 3</u>		5				
3076	Forward-current transfer ratio	$I_C = 5.0 \text{ Adc}$ $V_{CE} = 4.0 \text{ Vdc}$		$h_{FE}$	15	50	---
3076	Forward-current transfer ratio	$I_C = 10.0 \text{ Adc}$ $V_{CE} = 4.0 \text{ Vdc}$		$h_{FE}$	7.5	---	---
3071	Collector-emitter saturation voltage	$I_C = 5.0 \text{ Adc}$ $I_B = 500 \text{ mAdc}$		$V_{CE(sat)}$	---	1.25	Vdc
<u>4/</u>	Base-emitter voltage	$I_C = 5.0 \text{ Adc}$ $V_{CE} = 4.0 \text{ Vdc}$		$V_{BE}$	---	2.2	Vdc

1/ See 3.4 herein.2/ See 4.3.1 herein.3/ See 4.3.2 herein4/ See 4.3.3 herein.

Table II. Group B inspection.

Test Method per MIL-STD-750	Examination or test	Conditions 1/	LTPD Symbol	Limits		Unit
				Min.	Max.	
	<u>Subgroup 1</u>		20			
2066	Physical dimensions	---	---	---	---	---
	<u>Subgroup 2</u>		10			
2031	Soldering heat	1 cycle	---	---	---	---
1051	Temperature cycling	Test Cond. C	---	---	---	---
1056	Thermal shock (glass strain)	Test Cond. A	---	---	---	---
1021	Moisture resistance	No initial condition- ing	---	---	---	---
	<u>End-point tests:</u>					
3036	Collector-base cutoff current	Bias Cond. D V <sub>CB</sub> = 30 Vdc I <sub>E</sub> = 0	ICBO	---	100	uA <sub>dc</sub>
3076	Forward-current transfer ratio	I <sub>C</sub> = 5.0 A <sub>dc</sub> V <sub>CE</sub> = 4.0 Vdc	h <sub>FE</sub>	12.5	---	---
	<u>Subgroup 3</u>		20			
2016	Shock	Non-operating G = 500 5 blows of 1 msec. ea. in orientations X1, Y1, Y2, Z1 (total = 20 blows)	---	---	---	---
2006	Constant acceleration (centrifuge)	G = 10,000 Orientations X1, Y1, Y2, Z1	---	---	---	---
2046	Vibration fatigue	Non-operating	---	---	---	---
2056	Vibration, variable frequency	---	---	---	---	---
	<u>End-point tests:</u>					
	Same as for Subgroup 2, above					

Table II. Group B inspection-(Cont'd).

Test Method per MIL-STD-750	Examination or test	Conditions 1/	LTPD Symbol	Limits		Unit
				Min.	Max.	
<u>Subgroup 4</u>			10			
2/	High-temperature operation:	T <sub>A</sub> = + 150°C				
3036	Collector-base cutoff current	Bias Cond. D V <sub>CB</sub> = 30 Vdc I <sub>E</sub> = 0	I <sub>CBO</sub>	---	1.5	mA <sub>dc</sub>
<u>Subgroup 5</u>			20			
1046	Salt spray (corrosion)		---	---	---	---
<u>End-point tests:</u>						
	Same as for Subgroup 2, above					
<u>Subgroup 6</u>			20			
2036	Tension	Test Cond. A Fixed position = axis of unit vertical Attached weight = 10 lbs ± 10 oz (total) to ea. terminal Tension time = 10 ± 1 sec.	---	---	---	---
2036	Torque (stud)	Test Cond. D Torque = 12 lb./in. Torque time = 10 ± 1 sec.	---	---	---	---
2036	Torque (terminal)	Test Cond. D Torque = 24 ± 2 oz/in. applied to flat of ea. terminal Torque time = 10 ± 1 sec	---	---	---	---

Table II. Group B Inspection -(Cont'd).

Test Method per MIL-STD-750	Examination or test	Conditions 1/	LTPD Symbol	Limits		Unit
				Min.	Max.	
<u>Subgroup 6 -(Cont'd)</u>						
<u>End-points tests:</u>						
3036	Collector-base cutoff current	Bias Cond. D V <sub>CB</sub> = 30 Vdc I <sub>E</sub> = 0	I <sub>CBO</sub>	---	50	uAdc
3076	Forward-current transfer ratio	I <sub>C</sub> = 5.0 Adc V <sub>CE</sub> = 4.0 Vdc	h <sub>FE</sub>	15	50	---
<u>Subgroup 7</u>			λ=10			
1031	High-temperature life (non-operating)	T <sub>A</sub> = + 200°C				
<u>End-point tests:</u>						
Same as for Subgroup 2, above						
<u>Subgroup 8</u>			λ=10			
1026	Steady state operation life	T <sub>A</sub> = + 125° ± 3°C with heat sink P <sub>C</sub> = 65 W, min.				
<u>End-point tests:</u>						
Same as for Subgroup 2, above						

1/ See 3.4 herein.

2/ Test measurement shall be made after thermal equilibrium has been reached at the temperature specified.



Table II. Group C Inspection.<sup>1</sup>

Test Method per MIL-STD-750	Examination or test	Conditions <u>2</u>	LTPD Symbol	Limits	
				Min.	Max. or
	<u>Subgroup 1</u>		20		
3131	Thermal resistance	V <sub>CB</sub> = 30 Vdc	$\theta_{J-C}$	---	1.17 °C
1001	Barometric pressure, reduced (altitude operation):	Test Cond. D			
3036	Collector-base cutoff current	Bias Cond. D V <sub>CB</sub> = 30 Vdc I <sub>E</sub> = 0	ICBO	---	200 uA

<sup>1</sup>/ Periodicity for Group C inspection = initial lot, and thereafter on a lot every 90 days or every 5th lot, whichever occurs first.

<sup>2</sup>/ See 3.4 herein.

## 5. PREPARATION FOR DELIVERY

5.1 Preparation for delivery. - Preparation for delivery shall be in accordance with Specification MIL-S-19500.

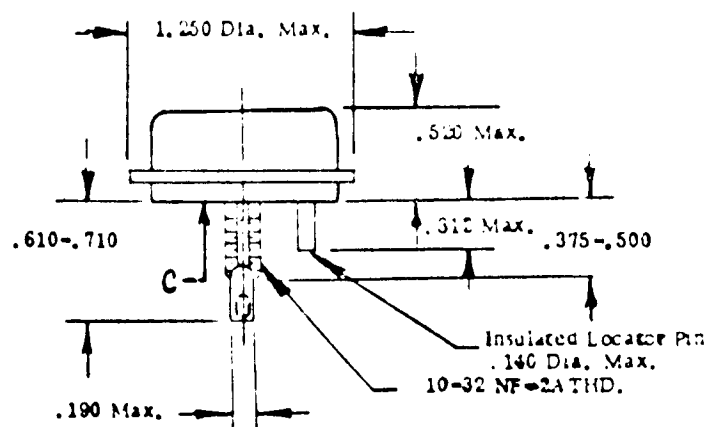
## 6. NOTES

6.1 Notes. - The notes included in Specification MIL-S-19500, with the following exceptions, are applicable to this specification.

6.2 Re-evaluation or verification inspection. - The LTPD method is exceptionally well suited for inspection at source, since it provides a high degree of assurance (90% confidence) that the lot represented has a proportion defective less than the specified LTPD value. However, the LTPD method is not suitable for inspection performed subsequent to source inspection since it provides, at most, a 10% confidence that the lot represented by a failure sample actually contains a proportion defective in excess of the specified LTPD value. As a result, whenever the quality of a lot is re-evaluated or verified by sampling inspection subsequent to the supplier's satisfactory demonstrations of compliance with the quality requirements, lot disposition should be based on a sampling plan which provides reasonable assurance that any lot rejected contains a proportion defective greater than the specified LTPD or  $\lambda$  value for any individual subgroup. When deemed necessary, the purchase order should specify the detailed criteria for lot disposition.

6.3 Qualification. - With respect to products requiring qualification, awards will be made only for such products as have, prior to the time set for opening of bids, been tested and approved for inclusion in Qualified Products List (QPL)-19500, supplement (Army), whether or not such products have actually been so listed by that date. Information pertaining to qualification of products covered by this specification should be requested from the Chief, Standardization Engineering Division, U. S. Army Electronics Materiel Support Agency, Fort Monmouth, New Jersey, attention: SELMS-PSM-3.

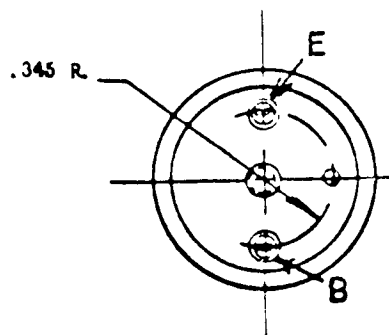
NOTES: When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any right or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

TERMINALS:

E = Emitter

B = Base

C = Collector (Case grounded)

NOTES

1. All dimensions in inches. Tolerances =  $\pm .005$  unless otherwise specified.

Figure 1. Outline and dimensions.